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Attention: [redacted]
Project Engineer, Change Detector

Subject: Recommendations for Change Detector Resolution Improvement

Reference: Telephone conversation [redacted] STATINTL STATINTL

Enclosure: Three (3) copies of [redacted] "Recommended Design Changes for Resolution Improvement to Change Detector" STATINTL

Gentlemen:

We are pleased to forward the accompanying report for your information and evaluation. It presents and discusses [redacted] investigation into the feasibility of improving the resolution of the present change detector design. Our findings indicate that the resolution design goal of 50 optical line pairs per millimeter, which we have adopted, is within the state-of-the-art of the components discussed. Attainment of this goal would most certainly add to the usefulness of the change detector. STATINTL

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[redacted] plans to visit [redacted] during the week of February 4th to discuss with you the details of this report. If you have any questions in the interim, feel free to contact [redacted] directly at [redacted] STATINTL

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We shall be happy to provide your facility with detailed costs for this improvement program if you will direct your inquiry to the attention of the undersigned.

Very truly yours,

[redacted]

CW/g

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RECOMMENDED DESIGN CHANGES FOR RESOLUTION IMPROVEMENT TO CHANGE DETECTOR

General

This report covers the results of study conducted to determine the feasibility of increasing the read-out resolution of the change detector currently under development. In order to determine the requirements on the various components of the system affected by a resolution increase, a design goal of 50 optical line pairs per millimeter (100 TV lines per millimeter) referred to the film planes has been established. The present design goal is 20 optical line pairs per millimeter (40 TV lines per millimeter). The following areas have been included in the resolution study: the cathode ray tube, power supply regulation and ripple requirements, dynamic focus requirements, optical focus requirements, and registration accuracy. In addition, methods for eliminating the raster lines from the faces of the display tubes in the monitors have been considered.

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overlap. The maximum read-out resolution obtainable is, therefore, inversely proportional to the spot diameter of the crt. A smaller spot diameter enables the raster to be shrunk in size, which results in higher read-out resolution. With the .0015 inch spot diameter tube installed in the breadboard system a maximum resolution of 22 optical line pairs per millimeter referred to the film is obtainable. The recently received .001 inch spot diameter tube gives a read-out resolution of 30 optical line pairs per millimeter. This data from the existing tubes enables the spot diameter required to meet the 50 optical line pairs per millimeter design goal to be calculated at .00065 inches. Several 5 inch tubes with .0006 inch spot diameters are available from different manufacturers. Although these tubes are developmental types, it is felt that they are sufficiently rugged and reliable for use in this system.

[redacted]

will be scanned on the 70 millimeter film planes. The "blow-up" or area enlargement under this condition is obtained by dividing the .5 inch diagonal measurement of the raster into the 14 inch diagonal measurement of the monitor tubes. The 28X area enlargement thus calculated is the point at which maximum resolution occurs. Further area enlargement to 40X is obtainable, however, no further increase in resolution will be available.

b. High Voltage Power Supply

One of the requirements that must be met to insure that the .0006 inch spot remains constant is that minimal ripple or other disturbances appear on the high voltage supply as the spot is deflected into a raster.

The deflection sensitivity of a crt (the distance the spot will deflect when a given deflection field is applied by the yoke) varies inversely with the square root of the accelerating voltage. [redacted]

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voltage for this tube can be tolerated. Several high voltage power supply manufacturers have been contacted to ascertain the feasibility of such a supply. Discussions with these manufacturers have determined that a power supply with these regulations and ripple characteristics is within the state-of-the-art and can be built.

Variations in the focus voltage for an undeflected spot also affect the spot diameter adversely. The method currently employed to obtain the focus voltage by dividing down from the high voltage supply will be adequate to prevent defocusing of the spot as long as the voltage tolerance for the high voltage supply is maintained.

c. Dynamic Focus

Flat face cathode ray tubes require a variation in the focus voltage (dynamic focus) as the spot is deflected out from the center of the tube in order to maintain uniformity in the spot size. Dynamic focus affects the system resolution most when the raster is shrunk down to a small size and is positioned at different points to observe "blow-ups" of various areas of the films. The dynamic focus requirement for the present design which utilizes the .001 inch spot diameter tube are not as severe as that for a .0006 inch spot. For example, only the raster position information is needed to adequately retain the resolution capabilities in the present design. To meet a 50 optical line pair per millimeter design goal, however, both raster position and raster amplitude information must be used for dynamic focus on the .0006 inch spot tube. Raster position information only focuses the spot accurately at the center of the raster. When the amplitude of the raster is also included in the dynamic focus, the entire raster will always be correctly in focus. Circuitry to add the raster position and raster amplitude information must be developed to provide the dynamic focus capability.

d. <u>Optics and Registration Considerations</u>

As the increase of resolution is obtained by reducing the spot diameter of the crt, the positioning of the elements involved in the imaging of the spot on the transparencies becomes proportionally more critical. The disturbance of the difference scene caused by lens distortions such as barrel, pincushion and keystone will become more evident with an improvement in the "acuity" of the system. The rigidity of the supporting mechanical elements must be increased to reduce the deflections due to their individual loadings to a value compatible with the more stringent requirements. The tightness of the joints and couplings of the mechanical linkages require upgrading. The fidelity of the motions associated with the optical formulae for positioning such as the magnification linkage and the X,Y position mechanism is also affected. The resolution of the servo position potentiometers must improve. The threshold of the servo must be reduced. The losses in resolution due to mirror quality in the azimuth deflection dove mirror system and prism quality in the nutation assembly require reviewing.

Since the improved resolution will be used to identify the nature of a change after a difference has been detected, a means of optimizing the focus when viewing a reduced area of one channel will be required. To accomplish this a vernier positioning of the lens or film plane would allow focusing.

To implement the vernier focusing the magazine, the servo mechanism that positions the magazine as a function of the magnification linkage will be upgraded. The nulling servo must be improved in accuracy and resolution. This will be accomplished by building a more precise mechanism and re-designing the position servo with higher resolution potentiometers for servo position pick-off. The vernier will be a biasing potentiometer located on the control panel. This vernier will be capable of driving the magazine through the focus range of the lenses.

The spread function of the rotating dove mirror system will be improved by a more precise mirror mount with flatter and more rigid mirrors. Also the optical flatness and glass quality of the nutation prisms will be more rigorously controlled.

<u>Raster Line Suppression</u>

Due to the operator's proximity to the monitors when the console is in use, the raster lines on the monitor crt's will be clearly visible in the present system. It is extremely difficult in this type of scanning system to make the raster less objectionable by increasing the number of lines in the raster. Speeding up the horizontal scanning rate to increase the number of lines creates technical problems in the system due to phosphor persistance of the scanning tube, increased video bandwidth requirements, increased deflection system requirements, and requirements for a special monitor design. A lowering of the vertical frame rate introduces a flicker in the scenes viewed on the monitors which is undesirable for real-time viewing.

A method is available which will suppress the raster lines from the monitor screens without affecting the system resolution. If the spot on the monitor crt's is deflected at a very high rate (15 megacycles or greater) in the vertical direction an amount equal to the distance between the lines in the raster no raster lines will be visible. This method commonly called "spot wobble" has been used effectively in television systems where close viewing of the monitor tubes is required. Special 14 inch monitor tubes can be built which are interchangeable with the existing monitor tubes with the exception that a set of electrostatic vertical deflection plates will be incorporated. These deflection plates coupled to oscillator circuitry to generate a 15 megacycle deflection signal will provide the necessary spot wobble for raster line suppression.

Conclusions

It is felt that with some design modifications and component changes a resolution design goal of 50 optical line pairs per millimeter as measured by a standard USAF test target is feasible. The increase in resolution can be accomplished by scanning a smaller area of the film than the present design with a .0006 inch spot diameter cathode ray tube. To fully utilize the higher resolution capabilities of this tube, the high voltage and focus supplies must be designed to a tighter tolerance. The dynamic focus circuitry must be modified to increase the resolution capabilities at the edges of the raster. A vernier drive on the lens focus must be provided to maintain the optical resolution capabilities of the system. Tolerances on other optical and registration components must be reviewed and reworked where necessary to adequately meet the design goal.

Suppression of the raster lines in the monitors by increasing the number of lines in the raster is not recommended for this system due to the severe technical problems which would arise. Vertical spot wobble, however, will satisfy this need with no degradation of system resolution.

Orientation Control

Simultaneous rotation of both film images to permit any desired orientation of the displayed images can be accomplished by a rotation of the scanning CRT raster. Rotation of the raster generation yoke appears to be the most feasible approach for the orientation function. The yoke must be rotated by a non-magnetic bearing material to avoid distortion of the magnetic fields. A teflon sleeve bearing will provide this capability. The drive motor must be mounted outside of the magnetic shield which surrounds the CRT to prevent its field from affecting the tube. One of the gear passes will enter through an opening in the shield to drive a gear mounted on the yoke. It is anticipated that a position servo will be employed for the orientation function with a potentiometer control on the front panel to indicate the angular displacement. In order to provide rotation about the center of the raster regardless of the area of the films being viewed, all position voltages must be removed from this raster generation yoke. In the present design the horizontal position signal is supplied by a separate yoke, but the vertical position signal is fed to the raster generation yoke. A special position yoke must be purchased to provide both horizontal and vertical position information for the CRT.

Description of Magazine for Change Detector[redacted]

The magazine will handle perforated or unperforated 70-mm film 250 ft. long. The aperture will remain 2-1/4 inch square. The film motion velocities will have two ranges, one from 0.02 inches per second to 0.20 inches per second and 2.5 inches per second to 24 inches per second. The velocities will be continuously variable through these ranges. A film length measuring roller will be used in conjunction with an adjustable ratio mechanism and a pulse switch to count frames with various lengths.

The film spools will be attached to magnetic particle clutches motor driven. The voltage into the magnetic clutches will be controlled as a function of the amount of film wrapped on the spool. This control will be accomplished through the use of a pot with a sensing arm attached to its shaft to determine the amount of film wrapped on the spool. The clutch control will be set to maintain the same tension on the film from each spool torque at low slew velocities.

A drive spindle will be used to drive the film with a servo motor-tachometer. The tachometer will be used as a feedback element for proportional velocity control. A duplex-clutch will accomplish the 120 to 1 gear ratio shift required for the positioning and slew velocities. A discriminator will be used to sense direction and magnitude of the fast slew velocity and unbalance the magnetic particle clutches in a manner that assures the frictional and inertial loads do not exceed the driving forces the drive spindle can impart to the film during the fast slew mode. The velocity servo in the fast slew shall have a network with a time constant in the loop to restrict the accelerations to a level bearable by the film.

The frame measuring roller will drive a disc type variable ratio device which will be calibrated to allow frame length to be inserted by using a dial. Since this control is to be made at the control panel the frame size adjustment will be made through the use of a position servo.

The film gate will be retracted during the slew and driving periods to reduce the probability of film damage. This will be accomplished by using a motor in parallel with the film driving motor.

The cross-hair servoes are packaged intimately with the film handling mechanism and must be packaged to be compatible with the configuration of the velocity type drive.